Summary

Food and environment

We consume food because we need food for a proper functioning of our body. But we do not eat food only because of the need, we also like food. Moreover the consumption of food could also has a cultural, social and entertaining function; besides a physiological value, food has an emotional value.

The production and consumption of food products is accompanied by releases of environmental pollutants, posing possible harm to humans and their natural environment. The use of nutrients and pesticides in agriculture may lead to emissions of minerals and (eco)toxic compounds to air, water, and soil. Together with a contribution to waste streams, packaging involves the use of materials and energy. Throughout the entire life cycle of food products, from agriculture, the food processing industry, the transportation sector, the trade sector, to households, energy is used. The use of energy gives rise to several environmental problems, like acidification, formation of photochemical compounds, depletion of natural resources and to the greenhouse effect. The use of energy can be viewed as a key parameter in the environmental assessment of products, goods or services.

Previous research showed that the household food consumption contributed for about 20% to the total household budget spending and the total energy use of an average Dutch household in 1990. Households use energy, both directly and indirectly. Direct energy use is the energy used by a household in the form of energy carriers like natural gas, electricity and petrol. Energy is also needed for the production of goods and for the delivery of services, the so-called indirect energy.

The use of energy is often associated with the (extra) greenhouse effect. The Inter-governmental Panel on Climate Change (IPCC) has concluded that the risk of human-induced climate change by these gases, possibly resulting in effects like rising sea level, shifts in geographical agricultural areas. The international community has committed themselves, in 1997 in Kyoto, Japan, to reducing the emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) by 5% in the period 2008-2012, as compared to the 1990 emission levels. The Netherlands aims at a 6% reduction. To develop a policy aimed at achieving these targets, one should start from a survey showing the most important contributors to the greenhouse gas emissions, to define the most effective options to reduce the emissions of these gases.

While Dutch household food consumption has a share of almost 20% in the total household energy use, food consumption also contributes for 20% to the CO_2 emissions. Therefore, feeding is a relevant household activity to look for options to reduce this energy use and greenhouse gas emissions.

This thesis focusses on the possibilities to reduce the energy use and the emissions of greenhouse gases (CO_2, CH_4, and N_2O), in such a way that Dutch household food consumption will meet the Kyoto-objectives in 2010. The impact of greenhouse gases is determined with Global Warming Potentials (GWP). A GWP-value indicates the relative contribution of a gas to the greenhouse effect. With a time span of 100 years, CO_2 has a GWP-value of 1, CH_4 and N_2O have a GWP-value of respectively 21 and 310.

Goal

To formulate options to reduce the total energy use and greenhouse gas emissions of food consumption, first the 1990 energy use and greenhouse gas emissions of Dutch household food consumption had to be determined. Energy is used and greenhouse gases are emitted in the entire life cycle of food production. Also, energy is used and greenhouse gases are emitted through food shopping, food storage and food preparation.

In this thesis the household energy use and greenhouse gas emissions are determined for Dutch households in 1990. Next, the possibilities to reduce this energy use and these emissions are investigated. With the main question: can the household activity feeding meet the greenhouse gas emission targets in 2010.

Methodology

To determine the total energy use and emissions of greenhouse gases of household food consumption two methodologies are used: Life Cycle Assessment (LCA) and hybrid energy analysis.

LCA is a methodology to determine the potential environmental impact of a product process or service. Life cycles are judged in physical terms, an LCA is a detailed but time-using method to determine the environmental impact of a chain. When products or processes are only judged on their energy use or emissions of greenhouse gases, like in this thesis, this can be called energy or greenhouse gas LCA.

The hybrid energy analysis is a combination of energy process analysis and energy based input-output analysis. Energy process analysis can be compared with an energy LCA, whereas energy input-output analysis stems from an economical methodology based on economic input-output tables. In an input-output tables financial transactions between economic sectors are given. With data about the energy use in the economic sectors, the direct and indirect energy flows through the economy can be determined. The energy input-output analysis, to determine the total energy use per delivered monetary unit of economic sectors, is a quick but less exact method compared to process analysis.

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In this thesis both methodologies are used to determine the energy use and greenhouse gas emissions of Dutch household food consumption. The methodology of LCA is used to determine the energy use and greenhouse gas emissions in the most important parts of food product life cycles. A computer model, the Energy Analysis Program (EAP) that is based on the hybrid method, is used to determine the energy and greenhouse gas intensities (in MJ/Dfl and kg/Dfl) of food products. These intensities are combined with information about 1990 household food spending, resulting in the total energy use and greenhouse gas emissions of 1990 household food consumption.

Greenhouse gas emissions

The emission of CO_2 is strongly related to the use of fossil fuels. Emissions of CH_4 and N_2O are only partly related to the use of fossil fuels.

The emissions of CH_4 and N_2O are strongly related to agriculture. CH_4 is emitted through anaerobic bacterial processes like 1) enteric fermentation in animals, 2) rice production, and 3) the production of manure. N_2O is emitted from the production of synthetic nitrogen fertilizers and from the application of both synthetic and organic fertilizers. A greenhouse gas analysis showed that for Dutch agricultural crops the emission of N_2O was dominant in terms of CO_2-equivalents. In cattle-farming CH_4 is the most important greenhouse gas.

Energy use and emission of greenhouse gas related to Dutch food consumption

After assessing the most important sources of energy use and greenhouse gas emissions in food product life cycles, the energy and greenhouse gas intensities were calculated for 125 different food products.

Combinations of these intensities with average household food spending, provided from the budget survey of the Central Office for Statistics (CBS), resulted in the total 1990 energy use and greenhouse gas emissions from Dutch household food consumption. In analogy to the budget survey of the CBS the 125 food products can be aggregated to seven food product categories: 1) bread, pastry and flour products, 2) potatoes, vegetables and fruit, 3) beverage and sugar containing products, 4) oils and fats, 5) meat, meat products and fish, 6) dairy products, and 7) other food products. The share of the different categories to the total energy use and CO_2 emission varies according to the household expenditures. The contributions of the food product categories to the CH_4 and N_2O emissions strongly differ from household expenditures. The food categories meat, meat products and fish, and dairy products determine the CH_4 emissions from household food consumption for more than 80%, whereas these categories account for only 40% of the total household food expenditures.

The CH_4 emissions from cattle farming determine the large share of these two food product categories. Meat, meat products and fish only contribute for 6% to the total N_2O emissions of Dutch household food consumption. The food product categories bread, pastry and flour products, potatoes, vegetables and fruit and dairy products contribute almost 70% to the total N_2O emissions of average household food product purchase, whereas households spend less than 50% of their food budgets on products in these categories.

The food product categories contribute differently to the energy use and greenhouse gas emissions. Differences in energy use and greenhouse gas emissions also exist within the food product categories. Various factors like production method determine the differences in energy use and greenhouse gas emissions of food products.

In total, Dutch household food consumption in 1990 leads to an energy use of 47.1 GJ and to greenhouse gas emissions of 4.2 tonnes CO_2-equivalents per average Dutch household. Almost 80% of the total food related greenhouse gas emissions stem from the CO_2 emissions, 15% from CH_4 and 5% from N_2O. A share of 30% of the total energy use and related CO_2-emissions of household food consumption is direct, while the emissions of CH_4 and N_2O are mostly indirect (95%).

Possibilities for energy and greenhouse gas emission reductions

The analysis of the total energy use and greenhouse gas emissions of household food consumption offers possibilities for reduction options. The analysis showed differences in energy use and greenhouse gas emissions of food products. The energy use and the greenhouse gas emissions of household food consumption are modelled with the help of a spreadsheet model. The model is constructed in such a way that reduction options could be formulated on the level of food product as well as on the level of life cycle stages. For the 1990 situation 27% of the total energy use and 39% of the total greenhouse gas emissions could be allocated to agriculture. The food processing industry contributed for 22% to the total energy use and for 17% to the total greenhouse gas emissions. The direct energy use (storage and preparation) contributes significantly to the total energy use (28%) and greenhouse gas emissions (23%) of Dutch household food consumption. Packaging contributes only for 6% to the total energy use and greenhouse gas emissions.

Two types of reduction options were formulated in this thesis: process related options and consumer related options. Process related options try to reduce the energy use and emissions of greenhouse gases in the various stages of food product life cycles. The process related options contain mostly technical measures, like combined heat power generation, energy care, chain management, and de-materialisation, to reduce the energy use and greenhouse gas emissions, but contain

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also the use of sustainable energy. In general, the various process related options reflect the policy of the Dutch government concerning the use of energy, like the voluntary agreements with various economic sectors. Various so-called Long Term Agreements (TLAs) have been closed between the government and economic sectors to increase their energy intensity. Furthermore, the process options follow the environmental policy plans regarding agricultural practices, like a reduction on the use of fertilizers and pesticides.

Households could reduce the energy use and greenhouse gas emissions from food consumption by changing their food consumption pattern. Food product selections that favour items with less energy use and greenhouse gas emissions are part of the attempts to reduce the energy use and greenhouse gas emissions of household food consumption. In case of food product substitution, besides the energy use and greenhouse gas emission content of the food products, the nutrition values of food products are very important. In this thesis the following nutrients are taken into account in case of food product substitution: protein, fat and carbohydrates content as energy supplier; content of vitamins B1 and B2, and the content of the mineral calcium. The substitution of food products may not lead to negative consequences for human health. In case of food product substitutions, the effects on the emotional value of food consumption is discussed.

The effects of the consumer options on the emotional value of food consumption are described qualitatively in this thesis. Other consumer options that are analysed are food shopping and kitchen appliances for meal preparation.

Reducing the energy use and greenhouse gas emissions of Dutch household food consumption

In this thesis it is assumed that the total Dutch food consumption is related to the growth of the number of households in the period 1990-2010. Because the number of households will increase by 32% in the period 1990-2010, the energy use and emissions of greenhouse gases related to food consumption will also increase by 32%. According to the Kyoto greenhouse gas emission targets a 6% decrease of the greenhouse gas emissions has to be achieved in 2010 compared to the 1990 Dutch emissions. Totally, for household food consumption the energy use and greenhouse gas emissions have to be reduced by 29% (0.38/1.32=0.29) in 2010.

With process related options a 25% reduction on the energy use and greenhouse gas emissions can be achieved. The LTA in glasshouse horticulture, supermarkets, and various food processing industries contribute mainly to this reduction. Other process related options, which contribute significantly to a lower energy use and to less greenhouse gas emissions are the use of renewable energy and technological improvements in kitchen appliances.

Beside process related options, consumers have possibilities as well to decrease the energy use and greenhouse gas emissions of household food consumption. With consumer related options the energy use and greenhouse gas emission of food consumption could be diminished by 2% to more than 10%. Changes in food consumption that contribute significantly to lower energy use and greenhouse gas emissions involve less meat consumption, meat substitution, consumption of more locally outdoor grown vegetables and less consumption of dairy products.

Process and consumer related options could result in a 35% reduction of the food related energy use and greenhouse gas emissions. When it is assumed that all goals of the process related options are met, a combination with consumer related options, may result in a 29% reduction of the energy use and greenhouse gas emissions. It is assumed to the following changes in food consumption patterns will occur:

- 10% less meat consumption (vegetables instead),
- the consumption of a vegetarian meal once a week,
- 50% more consumption of locally outdoor produced vegetables, and
- 10% less dairy consumption (coffee/tea, fruit and sugar containing products instead),

Such a consumption pattern does not influence the health of humans negatively. Human health could probably, for most people, even benefit from such changes in the food consumption pattern, in which the daily intake of proteins and fats will be diminished and the daily intake of carbohydrates will be increased.

With these changes in food consumption, together with the process options the household activity feeding can satisfy the greenhouse gas emission targets in 2010. Such changes in food consumption probably result in changes in the emotional judgement of food consumption. Less meat consumption can be valued negatively because people like meat, and because meat is associated with a certain status. However, avoiding animal distress by less meat consumption could be judged positively in terms of emotional values.

The consumption of more locally outdoor produced vegetables from the open ground will probably have a negative impact on the emotional value of food consumption. This is caused be a decrease in the diversity of the fresh vegetable supply. Less dairy consumption could also have a negative impact on the emotional value of food consumption of Dutch households. In the Netherlands, people are advised to consume many dairy products to maintain a good and strong bone system. Therefore, less dairy consumption might be associated with less healthier consumption, resulting in a lower emotional value of food consumption.

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Beside changes in food consumption patterns, other consumer options by which households could reduce their food related energy use and greenhouse gas emissions are less car use for food shopping and less (50%) and more efficient use of electric kitchen appliances. These two additional consumer options could increase the energy and greenhouse gas emission reduction to 32% in 2010 compared to 1990..

Conclusions

Beside this thesis, other research projects and activities in the field of feeding and environment are undertaken. These projects and activities are mostly directed at certain stages of the life cycle of food consumption and are mostly directed at a longer period than the period chosen in this thesis. The results of these projects and activities can be used in an integral approach, as presented in this thesis, to provide information about the environmental impact of food consumption.

Feeding is an important activity in households, and feeding is accompanied by energy use and greenhouse gas emissions. This thesis shows that besides the emissions of CO_2 it is important to include CH_4 and N_2O emissions to formulate options to reduce the energy use and greenhouse gas emissions of food products. To meet international emission targets in a society with a growing number of households, both process and consumer related options are needed. Process related options in combination with changes in household consumption patterns, in which less meat and more local grown vegetables are consumed, a 6% reduction of the total energy use and greenhouse gas emissions related to Dutch food consumption can be achieved in 2010 compared to 1990. For a complete view of the total greenhouse gas emission reduction, the other household activities should be taken into account. To determine the total environmental impact of food consumption, the environmental effects of food consumption on aspects like ecotoxicity should be considered.